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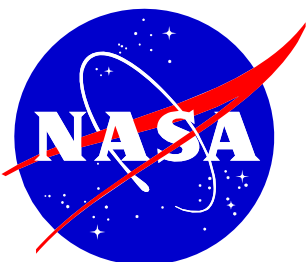
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LDCM Project

Mission Operations Element Requirements Document

November 21, 2006

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Signature Page

Prepared by:
Vicki Zanoni
LDCM Data Systems & Ops Manager
NASA GSFC Code 581

Date

Prepared by:
Jason Williams
LDCM Flight Operations Segment
System Engineer
SAIC, Contractor to the USGS EROS

Date

Reviewed by:
Evan Webb
LDCM Mission Systems Engineer
NASA GSFC Code 599

Date

Reviewed by:
Paul Cruz
LDCM Operations System Engineer
SAIC, Contractor to the USGS EROS

Date

Reviewed by:
Jeanine Murphy-Morris
LDCM Instrument Manager
NASA GSFC Code 427

Date

Reviewed by:

Reviewed by:
Del Jenstrom
LDCM Deputy Project Manager
NASA GSFC Code 427

Date

Reviewed by:

Date

Approved by:
William Ochs
LDCM Project Manager
NASA GSFC Code 427

Date

Approved by:
Tom Kalvelage
LDCM Project Manager
USGS

Date

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Document Revision History

This document is controlled by the LDCM Project Management. Changes require prior approval of the LDCM Project Manager, LDCM observatory Manager, and the LDCM Mission Assurance Manager. Proposed changes shall be submitted to LDCM Mission Systems Engineer.

RELEASE	DATE	BY	DESCRIPTION
-			Initial Version

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List of TBD's/TBC's/TBR's

This document contains information that is complete as possible. Items that are not yet defined are annotated with TBD (To Be Determined). Where final numerical values or data are not available, best estimates are given and annotated TBC (To Be Confirmed). If there is an inconsistency between two requirements then the best estimate is given and annotated with a TBR (To Be Resolved). The following table summarizes the TBD/TBC/TBR items in the document and supplements the revision history.

ITEM	REFERENCE	DESCRIPTION

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1 Introduction

1.1 Scope

The Mission Operations Element Requirements Document (MOERD) establishes the procurement requirements for the LDCM Mission Operations Element. It is a Level 3 document that contains the functional and performance requirements for the software and hardware systems comprising the Mission Operations Element.

Detailed requirements, design, implementation, and operation are not defined in this document. It is expected that the MOE will include all detailed functions needed to successfully operating the LDCM observatory for the life of the mission.

The grouping of functions within the sections of this document is strictly for organizational purposes. Grouping or categorizing requirements is not in any way intended to imply MOE system or sub-system architecture or design.

1.2 Mission Operations Element (MOE) Overview

The LDCM Mission Operations Element (MOE) is that part of the LDCM Flight Operations Segment that provides the primary means to communicate with the observatory and conduct the LDCM mission as described in the LDCM Operations Concept (Ref Doc. 427-02-02).

The MOE software and hardware systems will reside at the LDCM Mission Operations Center (MOC), a government facility located at TBD1. For operations contingency purposes a backup MOE (bMOE) will reside at a backup MOC (bMOC) facility, located at a geographically separate location from the MOC. The primary MOE and the bMOE interface for data transfer and operational transfer of observatory command and control.

The MOE consists of four primary functions:

- Command and Control
- Planning and Scheduling
- Trending & Analysis
- Flight Dynamics

The MOE functions are not intended to imply a particular MOE architecture or system design.

The Command and Control function generates, verifies, and sends observatory command loads for transmission to the observatory. Command loads are built to implement observatory activity schedules and flight software updates. The Command and Control

function monitors the LDCM observatory through the receipt, processing, and monitoring of observatory telemetry.

The Planning and Scheduling function builds and manages an activity schedule for the LDCM observatory. The schedule incorporates requests for image collections and non-routine instrument calibration requests that are generated by the Collection Activity Planning Element (CAPE) of the LDCM Flight Operations Segment. Refer to section 1.3 for further details. The MOE schedules the CAPE requested scenes, organizes them into intervals, and returns interval identifier to scene identifier mappings to the CAPE. The MOE performs planning and scheduling of the CAPE-requested and other observatory activities such as orbit adjustments, maneuvers, ground station contacts and other events that occur on board the observatory.

The Trending & Analysis functions process near- and long-term observatory telemetry data. This function is used to trend and analyze the performance of the observatory for state of health monitoring (e.g., potential problems with the observatory attitude, power, temperature, or other subsystems).

The Flight Dynamics functions provide orbit prediction, maneuver planning, definitive ephemeris generation, and ground station in-view data.

Updates to the LDCM observatory flight software will be provided to the MOE by the LDCM Mission Contractor. The MOE will build and send the flight software command loads to update the flight software on the observatory.

1.3 Overview of Data Collection Planning

This section is not intended to describe the MOE functionality. It illustrates the MOE role in the overall collection planning process and elaborates on the related interfaces.

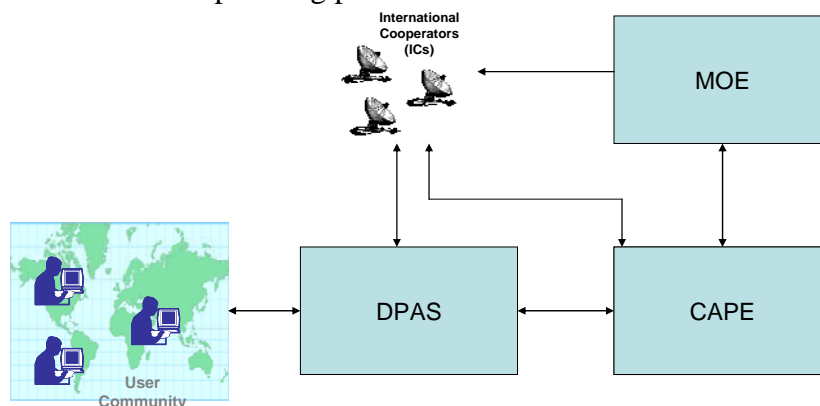


Figure 1-1 – LDCM data collection planning context

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The Collection Activity Planning Element (CAPE) is the LDCM component which determines the data (at a scene level) that will be acquired by the observatory's imaging sensor(s). The scenes to be collected are largely determined by a set of algorithms running with a set of global imaging requirements expressed as the Global Mission Acquisition Plan (GMAP). In addition to these, individual requests from agencies and users in the LDCM User Community are submitted through the Data Processing and Archiving Segment (DPAS). The DPAS forwards all requests to the CAPE for consideration. The CAPE also receives observatory and resource unavailability times from the MOE as in input to image data planning.

International Cooperators (ICs) typically submits requests for image data to the CAPE using a mask or table that provides the relative priority of scenes in their region. ICs may also submit requests for specific acquisitions through the same DPAS functionality as the rest of the User Community. ICs notify the CAPE of any ground station outages or desired changes in data collection.

The CAPE processes all these inputs (and others) to produce a final Collection Activity Request, which is a scene-based list of image data to be acquired by the observatory. This scene based list corresponds to nominal WRS-2 path/row footprints on the ground. The MOE ingests this list and uses it to generate the detailed spacecraft activity schedules, including determining imaging intervals. After doing the detailed observatory schedule the MOE informs the CAPE of the status of all the scenes in the Collection Activity Request. i.e. whether all the scenes requested by CAPE are scheduled on the observatory. The MOE also factors in observatory health & safety operations, orbital maneuvers and other operations which the CAPE is not involved in scheduling.

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2 Applicable and Reference Documents

2.1 Applicable Documents

The MOER is consistent with and responsive to the following applicable documents.

Document Number	Revision/Release Date	Document Title
427-XX-XX		LDCM Space Segment Requirements Document
GSFC STD-1000	Rev. A, May 30, 2005	Rules for the Design, Development, Verification and Operation of Flight Systems
NPD 8010.2D		NASA Policy Directive, Use of the SI (Metric) System of Measurement in NASA Programs
NPR 2810.1A	May 16, 2006	NASA Procedural Requirement, Security of Information Technology
450-SNUG	June 2002	Space Network (SN) Users' Guide, Revision 8
453-GNUG	February 2005	Ground Network (GN) User's Guide, Revision 1
452-ICD-SN/CSM	May 2004	Interface Control Document Between the Space Network and Customers for Service Management
CCSDS 231.0-B-1	September 2003	Recommendation for Space Data Systems Standards. TC Synchronization and Channel Coding. Blue Book. Issue 1.
CCSDS 231.0-B-1 Cor.1	June 2006	Recommended Standard Technical Corrigendum 1 to CCSDS 231.0-B-1, Issued September 2003. Blue Book. Issue 1.
CCSDS 232.0-B-1	September 2003	Recommendation for Space Data Systems TC Space Data Link Protocol. Blue Book. Issue 1.
CCSDS 232.1-B-1	September 2003	Recommendation for Space Data Systems Standards. Communications Operations Procedure-1. Blue Book. Issue 1.
CCSDS 133.0-B-1	September 2003	Recommendation for Space Data Systems Standards TM Space Packet Protocol. Blue Book. Issue 1.
CCSDS 131.0-B-1	September 2003	Recommendation for Space Data Systems Standards TM Synchronization and Channel Coding
CCSDS 732.0-B-1	July 2006	Recommendation for Space Data Systems Standards AOS Space Data Link Protocol
CCSDS 910.4-B-2	October 2005	Cross Support Reference Model – Part 1: Space Link Extension Services. Blue Book. Issue 2.

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Document Number	Revision/Release Date	Document Title
CCSDS 911.1-B-2	November 2004	Space Link Extension – Return All Frames Service Specification. Blue Book. Issue 2.
CCSDS 911.2-B-1	November 2004	Space Link Extension – Return Channel Frames Service Specification. Blue Book. Issue 1.
CCSDS 911.5-B-1	November 2004	Space Link Extension – Return Operational Control Fields Service Specification. Blue Book. Issue 1.
CCSDS 912.1-B-2	November 2004	Space Link Extension – Forward CLTU Service Specification. Blue Book. Issue 2.
CCSDS 912.3-B-1	November 2004	Space Link Extension – Forward Space Packet Service Specification. Blue Book. Issue 1.

2.2 Reference Documents

The following documents provide further context for the MOERD and the LDCM.

Document Number	Revision/Release Date	Document Title
427-02-06		LDCM Acronym List and Lexicon
427-02-02		LDCM Operations Concept Document
427-09-xx		MOE Statement of Work
427-xx-xx		Mission Assurance Requirements
427-05-04		OLI Special Calibration Test Requirements (SCTR)
White paper		LDCM World Reference System -2
NPR 7150.2		NASA Software Engineering Requirements

3 Command and Control

3.1 Commanding

The MOE shall communicate with the observatory in accordance with the following Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data Systems Standards:

- 231.0-B-1 Telecommand Synchronization and Channel Coding,
- 232.0-B-1 Telecommand Space Data Link Protocol,
- 232.1-B-1 Communications Operations Procedure-1, and
- 133.0-B-1 TM Space Packet Protocol.

Rationale: CCSDS compliance

The MOE shall be capable of generating commands to perform the observatory functions and requirements as defined in the LDCM Space Segment Requirements Document.

Rationale: overarching requirement for MOE to be able to command the observatory to perform any of its operational capabilities

The MOE shall provide the capability to generate commands to upload/implement Flight Software (FSW) modifications and updates.

Rationale: ability to send FSW to the observatory

The MOE shall be capable of generating commands to manage (enable / disable, start / stop, or cancel) observatory flight software command sequences.

Rationale: ability to start an update or stop it after it has been started

The MOE shall be capable of generating commands to execute and control observatory attitude and orbit maneuvers.

Rationale: maneuver command capability

The MOE shall provide the capability to command the observatory into any operational or non-operational mode.

Rationale: covers all modes on the observatory

The MOE shall provide the capability to perform real time commanding to the observatory.

Rationale: allows operator to generate and send command loads/sequences during a contact, as automated upload of pre-staged commands

The MOE shall perform verification of real-time commands to the observatory.

The MOE shall provide the capability to generate, uplink, and verify discrete observatory commands.

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Rationale: allows operators to generate and send individual or syntax-based commands instead of as part of a larger load or sequence

The MOE shall provide the capability to generate command procedures via a user-friendly scripting language.

Rationale: automates the execution of command sequences on the ground that varies based upon observatory state or operator input. See the definition of “procedure” in the glossary.

The MOE shall provide a capability to generate time-tagged stored command sequences using absolute time.

The MOE shall provide a capability to generate time-tagged stored command sequences using relative times.

The MOE shall provide the capability to identify and designate critical commands in the command database.

Rationale: flagging of commands that could jeopardize the health and safety of the observatory or its subsystems, under certain conditions.

The MOE shall employ at least one additional operator confirmation prior to the use of a critical command in a command load or in real-time commanding.

Rationale: creates operator intervention for critical commands; Ensures that operator has to provide additional approval before command is used in a command load or in real-time.

The use of additional operator confirmation(s) prior to critical commanding shall be enabled and disabled via system parameter and/or command.

Rationale: Provides support for autonomous commanding

The MOE shall provide the capability to identify and designate hazardous commands in the command database.

Rationale: flagging of commands that may endanger the safety of human beings working on the observatory during I&T, launch preparation or launch.

The MOE shall ensure that hazardous commands cannot be transmitted to the observatory.-

Rationale: ensures that hazardous commands cannot be sent to the observatory until they are no longer flagged as hazardous.

The MOE shall employ at least one additional operator approval or rejection step prior to the removal of critical and hazardous command designations in the command database.

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Rationale: creates operator intervention for removal of hazardous and critical command flags

The use of additional operator confirmation(s) prior to the removal of critical or hazardous command designations shall be enabled and disabled by system parameter. .

The MOE shall provide the capability to assign levels of command authority to ensure that only authorized personnel can perform designated command functions.

Rational: provides ability to assign different command privileges to different personnel.

The MOE shall provide the capability to allow authorized operators to transmit commands to the observatory.

Rationale: The MOE shall provide the capability to deny unauthorized operators access to system capabilities.

The MOE shall prevent concurrent sending of commands by multiple operators.

Rationale: only one operator or terminal can send commands to the observatory at a time

The MOE shall provide the capability to allow authorized operators to edit command loads.

Rationale: The MOE shall provide the capability to deny unauthorized operators access to system capabilities.

The MOE shall provide the capability to allow operators to display command loads in hex and interpreted formats.

The MOE shall provide the capability to report the status of command load generation.

Rationale: allows operators to know the state of command loads that may each be in different stages of development and to know the completion status of automated processing steps.

The MOE shall report the status of command load uplink by the ground station.

Rationale: allows operators to know if a load was uplinked successfully.

The MOE shall be capable of performing automatic constraint and rule checking of discrete commands and command loads.

The MOE shall be capable of performing manual constraint and rule checking of discrete commands and command loads.

The MOE shall provide the capability to modify or edit command rules and constraints.

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The MOE shall preclude the transmission of commands or command sequences that have not been constraint or rule checked.

The capability to preclude transmission of commands or command sequences that have not been constraint or rule checked shall be enabled and disabled by system parameter and/or command.

The MOE shall provide notification to the operator of any invalid commands.

The MOE invalid command notifications shall include the specific reason for command transmission failure.

Rationale: operator feedback as to the nature of the command invalidity (e.g. “cmd not found”, “sub-mnemonic out of range”, etc)

The MOE shall have the capability to perform commercially available command encryption compliant with NPR 2810.1A.

Rationale: project requirement based on the type of mission and threat assessment; provide protection against unauthorized attempt to command observatory

The MOE shall provide the capability to enable and disable the command encryption function.

Rationale: ability to turn off/on encryption if needed

The MOE shall provide the capability to authenticate all commands as originating from the LDCM MOE.

Rationale: additional level of security to ensure that commands are from the authorized source

The MOE shall provide the capability to enable and disable the command authentication capability.

Rationale: authentication may need to be disabled during emergency or contingency operations

The MOE shall be capable of notifying the operator that the commands sent to the observatory were correctly received.

The MOE shall provide the capability to manually retransmit commands or command loads that were not accepted by the observatory.

The MOE shall provide the capability to autonomously retransmit commands or command loads that were not accepted by the observatory.

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The MOE shall be capable of an operator-specified number of autonomous command retransmission attempts.

Rationale: allow for N number of automatic retransmission attempts before stopping

The MOE shall provide the capability to enable and disable the autonomous command retransmission capability.

Rationale: ability to turn on/off automated retransmission function

The MOE shall define observatory commands and their characteristics in a command database.

The MOE shall have the capability to search and sort observatory commands defined in the command database.

Rationale: allows for ease in building command sequences

The MOE command database shall allow the referencing of commands and command sequences based on mnemonic specification.

Rationale: provides logical IDs for commands

The MOE shall provide the capability for operators to edit and modify the command database.

Rationale: permits the addition, deletion, editing of entries, fields and attributes

The MOE shall archive all command operations and command history for the life of the mission in raw (hex) and interpreted formats.

Rationale: provides a time-tagged history of all commands sent to observatory

The MOE shall be capable of concurrent commanding, real-time housekeeping telemetry receipt/ingest, stored housekeeping telemetry receipt/ingest, and telemetry playback.

Rationale: allows MOE to perform telemetry ingest and commanding at the same time

The MOE shall provide the capability to generate LDCM Ground Network (LGN) forward and return link service requests.

Rationale: MOE must acquire link through LGN before commanding

The MOE shall provide the capability to generate NASA Space Network (SN) forward and return link service Ground Control Message Requests (GCMRs) consistent with the Interface Control Document between the Space Network and Customers for Service Management.

Rationale: GCMRs are sent to SN to acquire the SN link; should use a user-friendly GCMR utility

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The MOE shall provide the capability to generate NASA Space Network (SN) forward and return link service Ground Control Message Requests (GCMRs) based on activity schedules.

Rationale; ability to feed from schedules to generate GCMRs; supports automation requirements

The MOE shall be capable of conducting handoffs between LGN, NASA Ground Network (NGN), and Space Network with overlapping observatory view periods with no loss of data.

Rationale: allows handoff from one ground station to another

The MOE shall have the ability to configure the forward, return and status data streams between any ground station automatically based on the schedule or manually from the command console via directive.

Rationale: ability to establish links for commanding and telemetry; ensure only one station sends command to the observatory at a time

The time to configure forward, return, and status data streams between ground stations shall not exceed 5 seconds.

Rationale: quick configuration to set up link to observatory

The MOE shall identify the LGN station, NGN station, or SN resource that is communicating with the observatory.

Rationale: To provide the MOE operators positive identification of the "in-use" resource

The MOE shall be capable of reconfiguring to communicate with the LGN, NGN, and SN.

Rationale: configuration control and management for ground stations or SN communications

The MOE shall be automatically synchronized to a GFE-provided external master time signal reference.

Rationale: Allows time across the various MOE systems to be synchronized with a time source that stays accurate without operator intervention. This ensures that ground timestamps on data, event logs, etc. remains accurate.

The MOE shall convert UTC reference time to observatory reference time.

Rationale; converts observatory TAI (GPS time without leap seconds) to UTC

The MOE shall convert to UTC reference time from observatory reference time.

Rationale; converts observatory TAI (GPS time without leap seconds) from UTC

3.2 Telemetry Processing and Reporting

The MOE shall accept telemetry from the observatory in accordance with the following Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data Systems Standards:

- 131.0-B-1 TM Synchronization and Channel Coding,
- 732.0-B-1 AOS Space Data Link Protocol, and
- 133.0-B-1 TM Space Packet Protocol.

Rationale: *CCSDS compliance*

The MOE shall provide the capability to decommutate all housekeeping telemetry based on the telemetry database.

Rationale: *establishes that decom is driven by a database*

The MOE shall provide the capability to replay housekeeping telemetry based on an operator-specified start and stop time and replay rate.

The MOE shall provide the capability to specify the replay of housekeeping telemetry by ground receipt time or spacecraft time.

The MOE shall be capable of processing and reporting all housekeeping telemetry.-

The MOE shall be capable of assessing quality of the currently available telemetry parameter value.

The MOE shall provide the capability to convert telemetry counts into Engineering Units (EUs) using predefined database conversion operators such as but not excluding: polynomials, equations, lookup, supercom, logarithmic, splines, pseudo, bit ordering, etc..

The MOE shall be capable of providing temporary overrides for polynomial definitions.

Rationale: *Modify polynomial conversion coefficients for test or until database update.*

The MOE shall provide the capability to display operator-selected telemetry data in real time.

The MOE telemetry display shall provide data quality indicators.

The MOE shall provide the capability to display discrete telemetry parameters with operator-defined text or numeric values in real time.

The MOE shall provide a capability to verify in real-time that telemetry parameters are within prescribed operating limits.

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The MOE shall provide the capability to display telemetry limit flags (states).

The MOE shall provide a capability for operators to temporarily and permanently define and modify telemetry parameter limit conditions.

Rationale: temporary changes are intended to handle situations where a limit change is needed, but the telemetry database has not yet been changed. Permanent changes are intended to be changes made to the telemetry data base.

The MOE shall provide an operator-configurable color coding scheme to display telemetry relative to limit ranges.

Rationale: without specifying a particular approach, this requires an easily interpretable limit display to determine spacecraft health and safety. , e.g. Red-High (RH), Yellow-High (YH), Green, Yellow-Low (YL), and Red-Low (RL). This is configurable to accommodate various forms of color-blindness.

The MOE shall provide an operator-configurable non-color-coded scheme to display telemetry relative to limit ranges.

Rationale: This is identification of limit display using fonts, symbols, flashing text etc.

The MOE shall perform conditional limit sensing utilizing two or more sets of defined limits based on a user defined switch parameter value.

Rationale: Provides reliable limit sensing ranges based on defining parameter (telemetry, etc) values.

The MOE shall provide the capability for notification of limit violations only after an operator-specified number of consecutive limit failures.

Rationale: Addresses limit persistence - the ability to set how many consecutive points which exceed the limit values must be received before a limit failure is reported (and the telemetry point's state changed).

The MOE shall provide the capability to generate event messages when limit state transitions occur.

The MOE shall provide a capability to turn ON and OFF all limit checks, groups of limit checks or individual limit checks.

Rationale: Groups would be identified in the telemetry data base (e.g., associating a group of parameters to a particular subsystem).

The MOE shall perform session monitoring and sequence error checking on active links between ground stations and the MOE.

Rationale: quality checking on link and data transfer during communications

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The MOE shall provide the capability to create observatory contact summary reports.

Rationale: These reports summarize the contact activities and results, including data collection statistics and summaries.

The MOE shall provide the capability to ingest and process real-time status/control messages from the LGN.

Rationale: Allows telemetry and command functions to process key status information about the quality of data received in an LGN contact.

The MOE shall provide the capability to ingest and process real-time status/control messages consistent with the Interface Control Document between the Space Network and Customers for Service Management.

Rationale: Allows telemetry and command functions to process key status information about the quality of data received in an SN contact.

The MOE shall prevent ingest of stale or invalid telemetry.

Rationale: rejection of telemetry that is not in a recognizable format and can not be de-commutated or is de-commutated but contains incorrect/invalid values, etc. Rejects telemetry received that has old time stamps not synchronized with current system time.

The MOE shall provide the capability to notify the operator when stale or invalid telemetry is detected.

Rationale: signals ops team when bad telemetry is detected

3.3 Event and Logging Operations

The MOE shall provide the capability for operators to create and modify the conditions when event messages are generated.

Rationale: ability to modify event conditions in the database

The MOE shall provide the capability for operators to create and modify the content of event messages.

Rationale: ability to modify event message text in the database

The MOE shall time tag all event messages with a UTC time.

Rationale: Allows operator to correlate ground system and spacecraft events.

The MOE shall provide an operator-configurable color coding scheme to display event messages.

Rationale: without specifying a particular approach, this requires an easily interpretable means of identifying alarms, warnings and routine messages. , e.g. Red for alarms, yellow for warnings, blue for routine messages, etc. This is configurable to accommodate various forms of color-blindness.

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The MOE shall provide an operator-configurable non-color-coded scheme to display event messages.

Rationale: This is identification of event message displays using fonts, symbols, flashing text etc.

The MOE shall provide the capability to generate operator-defined event message reports.

The MOE shall allow the operator to enable, disable, filter, and display event messages.

The MOE shall provide an operator-configurable control to filter repeated event messages.

Rationale: Allows operator to prevent the same event message from occurring over and over in the event log. You may not want the same limit violation repeated over and over again, but rather on every nth occurrence

The MOE shall provide the capability to log all event messages for the life of the mission.

The MOE shall provide the capability to display any event messages and logs.

The MOE shall provide a capability to generate and save operator logs.

Rationale: keep a record of operator interaction with the system

4 Planning and Scheduling

The MOE shall provide the capability to generate command loads from de-conflicted observatory activity schedules.

Rationale: schedules form the basis of commands

The MOE shall provide the capability to plan and schedule all observatory housekeeping and maintenance activities for the life of the mission.

The MOE shall generate a WRS path/row to time translation table.

Rationale: accurate timing data that must be provided to the CAPE for image collection planning

The MOE shall produce time-ordered activity plans listing all planned activities for the observatory planning window.

The MOE shall convert CAPE-provided requests into observatory activities.

Rationale: converts the CAPE-generated scene and any other requests to imaging intervals and/or recorder on/off times, off-nadir, IC downlinks, etc.

The MOE shall plan and schedule observatory imaging intervals.

Rationale: MOE-planned imaging intervals would likely be a default imaging mode or a reserved collection allocation, as driven by chosen ops procedure

The MOE shall provide the capability to incorporate activity requests into an activity plan.

Rationale: requires the inclusion of image collection requests from CAPE and other observatory activities into an activity plan

The MOE shall provide the capability to automatically update activity plans as activity requests are received.

Rationale: allows automatic update to a plan, if a new request is received during the planning process (prior to scheduling)

The MOE shall automatically process all activity requests that fall into the current scheduling window, when generating a schedule.

Rationale: requires that when a schedule is being generated, all activity requests for the current scheduling period are used as input. i.e. for a 72-hour window, any activity in memory that falls into that 72 hour period will be automatically read

The MOE shall provide the capability to create and modify activity priorities, constraints, and rules.

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The MOE shall automatically check for activity constraint and rule violations during schedule generation.

The MOE shall automatically check for resource constraint and rule violations during schedule generation.

The MOE shall provide a capability to notify operators of conflicts, activity and resource constraint violations, and activity rule violations during planning and scheduling.

The MOE shall incorporate all resource down times or reserved times into schedule generation.

The MOE shall provide the capability to automatically schedule all observatory and ground station activities within operational resource constraints.

The MOE shall provide the capability to automatically de-conflict unavailable observatory resources.

The MOE shall provide the capability to produce a Coordinated Universal Time (UTC) time-based activity schedule in terms of specific start/stop times.

The MOE shall be capable of converting to and from UTC reference time to the observatory reference time.

Rationale: Allows MOE products and processes to be time-tagged in either format

The MOE shall provide the capability to generate a conflict-free activity schedule spanning 72-hours (TBC2) of activity.

Rationale: consistent with time of unstaffed operations

The MOE shall provide the capability to generate a conflict-free activity schedule every 12 (TBC3) hours.

Rationale: for nominal ops, allows generation of new schedules every 12 hours, consistent with cloud-cover prediction inputs

The MOE shall provide the capability to generate a conflict-free activity schedule in 3.5 (TBC4) hours or less, including operator interaction time.

Rationale: allows FOT to generate new schedules within 3.5 hours for priority activities

The MOE shall provide the capability to schedule a contact within 15 minutes (TBC1) of an in-view observatory contact.

Rationale: For emergencies

The MOE shall provide the capability to report activity schedule generation status.

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The MOE shall provide the capability to manually modify an activity schedule.

The MOE shall provide the capability to generate a graphical timeline of activity plans and schedules.

The MOE shall provide the capability to generate operator-defined planning and scheduling reports.

The MOE shall provide a display of planned, currently active and past observatory and ground activities.

Rationale: notification of what has happened, will happen or what is happening in the observatory or ground

The MOE shall be capable of saving and printing all mission planning and scheduling data for the life of the mission.

Rationale: provides operator functions of saving and printing

The MOE shall be capable of storing all mission planning and scheduling data for the life of the mission.

Rationale: provide long term storage of plans and schedules

5 Trending and Analysis

The MOE shall provide the capability to ingest and store all telemetry for the life of the mission.

Rationale: supports ability to perform MOE trending and analysis of all telemetry data

The MOE shall perform limit sensing utilizing a user defined set of parameters and limits.

Rationale: Perform “back-orbit” limit sensing of telemetry.

The MOE shall provide the capability to display operator-selected telemetry data for any operator-specified time interval.

The MOE shall provide the capability to define pseudo-telemetry via operator-defined equations.

Rationale: Provide the ability to perform mathematical operations on telemetry points to create pseudo-telemetry values.

The MOE shall have the ability to set a sample filter rate for trended telemetry.

Rationale: Provide some user control of output generation times.

The MOE shall provide the capability to display discrete telemetry parameters with operator-defined text or numeric values.

The MOE shall provide the capability to export operator-specified telemetry data to current PC-based media, standard desktop software applications, and via the internet.

The MOE shall be capable of displaying multiple sets of stored telemetry data concurrently for 2 or more operators during nominal operations.

Rationale: allows at least 2 operators to view telemetry at the same time

The MOE shall be capable of generating trending products from real-time telemetry.

The MOE shall be capable of generating trending products from stored telemetry.

The MOE shall be capable of generating statistical products from real-time telemetry.

The MOE shall be capable of generating statistical products from stored telemetry.

The MOE shall provide the capability to generate trending and statistical products for any operator-specified time interval.

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The MOE shall be capable of generation of trending and statistical products by 2 or more concurrent operators during nominal operations.

The MOE shall provide the capability to indicate limit values on trending and statistical displays and reports.

The MOE shall provide the capability to generate trending products and statistical products for an operator-defined time period.

The MOE shall provide the capability to both manually and automatically generate trending products and statistical products.

Rationale: Product generation can be under direct operator control, activity schedule or application triggers internally defined (ie. Time of day or percent data collected, etc)

The MOE shall be capable of generating a trending and statistical product for up to 5 telemetry parameters in 5 minutes (TBC5) or less, from the full set of telemetry data.

Rationale: product performance requirement for the full mission life

The MOE shall display a single requested telemetry value from the full telemetry data set in 2 minutes (TBC6) or less.

Rationale: data retrieval performance requirement for the full mission life

The MOE shall provide a capability to trend basic statistical products including minimum, maximum, and mean values at a minimum.

Rationale: allows feeding of standard statistical products through trending function; support long term trending

The MOE shall provide the capability to display telemetry parameters in either raw or engineering unit (EU)-converted format.

6 Flight Dynamics

The MOE shall provide the capability to perform observatory maneuver planning for the life of the mission.

The MOE shall be capable of generating maneuver plans in support of all observatory orbit maintenance, calibration, imaging, and decommissioning activities.

Rationale: Key function and SMRD traceability.

The MOE shall be capable of automatically generating off-nadir imaging maneuver plans.

The MOE shall provide the capability to automatically identify and report maneuver constraint violations during maneuver planning.

The MOE shall provide the capability to automatically detect and notify MOE operators when the observatory orbital parameters deviate from established limits.

The MOE shall provide the capability to maintain an observatory ground track to WRS-2 grid within +/- 5 Km at the equator.

Rationale: key function; SMRD traceability

The MOE shall provide the capability to propagate the observatory orbit to the following accuracies, assuming a solar flux (F10.7) value of less than 215 (10^{-22} W/m²/Hz) and no maneuver activity during the propagation interval:

Accuracy of predicted orbit state vectors for the first forty (40) hours shall be no worse than the following (TBC7):

7 meters (3s) radial
375 meters (3s) along-track
10 meters (3s) cross-track
375 meters (3s) RSS

Accuracy of predicted orbit state vectors at 72 hours shall be no worse than the following (TBC7):

12 meters (3s) radial
1200 meters (3s) along-track
12 meters (3s) cross-track
1200 meters (3s) RSS

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The MOE shall provide the capability to propagate the observatory orbit for operator-defined durations.

Rationale: need for orbit prediction / maneuver planning; parent requirement to predicted ephemeris generation

The MOE shall provide the capability to generate the definitive ephemeris of the observatory at an accuracy of 30m in each axis, 3 sigma.

Rationale: value-added processing of GPS ephemeris in telemetry

The MOE shall generate definitive ephemeris for the previous 36 hours, every 12 (TBR) hours.

Rationale: can be used by DPAS if observatory-generated ephemeris within ancillary data is not accurate enough for image processing

The MOE shall generate attitude history for the previous 36 hours, every 12 hours.

Rationale:

The MOE shall provide the capability to both manually and automatically generate flight dynamics products and subsequently distribute these products.

Rationale: Product generation can be under direct operator control, activity schedule or application triggers internally defined (ie. Time of day or percent data collected, etc)

The MOE shall be capable of accepting and uploading externally-generated attitude sensor calibration data.

Rationale: receipt and implementation of bus-provider's sensor cal updates

The MOE shall provide the capability to calibrate the observatory thrusters

Rationale: to perform thruster cal using maneuver reconstruction after each burn.

The MOE shall provide the capability to monitor and predict observatory consumable usage throughout the life of the mission.

Rationale: propellant (maneuver planning), battery state of charge, storage capacity, etc.

The MOE shall provide a capability to display the observatory orbit and ground tracks based on operator-defined durations.

The MOE shall be capable of ingesting externally-generated observatory ephemeris data.

Rationale: in the event of a GPS failure, allows MOE to use ephemeris from external source

The MOE shall be capable of exporting ephemeris and attitude data for an operator-selectable time interval to current PC-based media, standard desktop software applications, and via internet.

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The MOE shall provide the capability to generate predicted ground station contact/view periods for the observatory.

Rationale: accuracy for in-view is derived from orbit propagation accuracy

The MOE shall incorporate ground station antenna masks in computing predicted station contact/view periods.

The MOE shall not allow commanding of the observatory when the elevation angle from the station to the observatory is less than a configurable command angle limit.

Rationale: provides the capability for the FOT to put a lower limit on contact angles to use for commanding, to avoid low-angle link issues.

The MOE shall provide a capability to generate predicted SN contact/view periods for the observatory.

The MOE shall provide the capability to generate observatory acquisition data for ground stations.

Rationale: provides capability to generate two line elements (TLE), Brouwer mean element (BME) and improved inter range vectors (IIRV) for ground stations.

The MOE shall generate observatory acquisition data for the SN.

Rationale: provides capability to generate two line elements (TLE), Brouwer mean element (BME) and improved inter range vectors (IIRV) for TDRSS.

The MOE shall provide the capability to model sun-line RF interference between the observatory and ground stations, and between the observatory and the SN.

The MOE shall provide the capability to generate operator-specified flight dynamics and maneuver planning reports.

Rationale: ability to produce products such as view periods, eclipse entrance/exit, ascending/descending node, solar beta angle

The MOE shall report and plot attitude with respect to operator selected reference frames.

Rationale: such as LVLH, J2000 inertial, orbital reference, and earth-fixed

7 Memory Management

7.1 Flight Software Management

The MOE shall provide version control for Ground Reference Image (GRI) of observatory memory.

Rationale: Required to provide health/status of on-board computers; required to enable reload of flight software executable from ground segment in case of single event upsets or other anomalies.

The MOE shall provide the capability to modify any re-programmable/writeable memory locations on the observatory.

Rationale: SW updates for actuators, sensors, processors, etc.

The MOE shall be capable of exporting observatory memory dump data to current PC-based media, standard desktop software applications, and via internet.

Standard requirement to allow effective data management of memory dump data.

The MOE shall provide the capability to compare multiple memory dumps and report the specific differences.

Rationale: Required for OBC memory management.

The MOE shall provide the capability to compare memory dumps with the GRI and report the specific differences.

The MOE shall provide the ability to view the Ground Reference Image.

The MOE shall provide the ability to view observatory memory dumps.

The MOE shall be capable of displaying memory tables in human-readable format.

7.2 Mass Storage Management

The MOE shall generate and assign a unique interval identifier, based on an identifier scheme defined in conjunction with the Government.

Rationale: allows ground to generate the interval ID. Allows data to be tracked through entire LDCM operations and science data processing systems per Level II requirement. Unique interval identifiers will be the same as root file IDs in observatory mass storage for ease in recorder management. See SSRD requirement.

The MOE shall generate and maintain the scene to interval identifier mapping table.

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Rationale: since CAPE selects scenes and MOE assigns intervals and root file ID, the MOE must keep track of the linkage between the two. Observatory will assign specific file names based on a scheme defined in conjunction with the Government.

The MOE shall be capable of designating imaging intervals as Priority.

Rationale: The MOE must flag priority intervals so that the ground system can expedite the downlink of the scene/interval. Prioritization of playback data is strictly done on ground. If one scene within a long interval is priority, FOT can schedule that scene as its own interval.

The MOE shall be capable of designating imaging intervals as Protected.

Rationale: The MOE must flag protected scenes or the interval and file it resides in, so that the observatory does not overwrite them. Expect that standard ops will be to protect all data on board until it is downlinked.

The MOE shall be capable of removing the Priority and Protected designations from imaging intervals.

Rationale: Ability to remove flags within the MOE

The MOE shall generate mass storage commands using interval/root file identifier designations.

Rationale: file -based recorder management capability; root file IDs are the same as interval IDs

The MOE shall be capable of generating mass storage commands using memory location designations.

Rationale: capability for location-based recorder management capability, if file naming gets corrupted

The MOE shall command data in mass storage to be unprotected.

Rationale: If observatory mass storage contains protected data, only the MOE will be able to command files or locations to be unprotected in mass storage and available for overwriting. Expected standard ops are to command data to be unprotected when it has been receipt-acknowledge by ground.

The MOE shall provide a capability for operators to select data in mass storage for downlink.

Rationale: Allows the ground to determine what files or locations to downlink and re-downlink when.

The MOE shall display file directory listings, tables, and dump data in human readable formats.

Rationale: ability for operators to view and interpret tables and dumps

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The MOE shall provide the capability to model current and predicted observatory mass storage utilization.

Rationale: Allows MOE to monitor and plan on-board recorder usage

The MOE mass storage modeling capability shall accept observatory data collection and downlink planning and scheduling inputs.

Rationale: future collection and downlink activities must feed model in order to have an accurate representation for planning purposes

The MOE mass storage modeling capability shall accept observatory housekeeping telemetry inputs.

Rationale: to accurately model the state of mass storage, the model should feed from telemetry

The MOE mass storage modeling capability shall provide a textual and graphical display.

Rationale: operators must be able to view and interpret mass storage model data

The MOE shall provide a configurable capability to automatically commanding the observatory to downlink Priority files first, then the oldest files in mass storage.

Rationale: For unattended operations, the MOE can direct the downlink priority first, then oldest to youngest

The MOE shall provide a configurable capability to automatically command the retransmission of data files based on the status received from the LGN.

Rationale: This capability allows autonomous commanding of data retransmission, thus achieving a class 2 service outcome as defined in the CCSDS CFDP standard.

The MOE shall provide a reconfigurable capability to automatically command the observatory to unprotect files in mass storage based on the status received from the LGN.

Rationale: once MOE receives acknowledgements from LGN, MOE can automatically allow these files to be overwritten on the observatory

The MOE shall generate a playback data accounting summary for each observatory downlink session supported, to include the following information: a) File name of each file received b) data type/source (want this to be part of file name) c) byte-size for each file d) File Acknowledgement Flag e) number of pending File Retransmission Requests buffered for this pass.

Rationale: Generation of playback accounting summaries is required to ensure data completeness and integrity for the stored science and engineering data replayed during ground station contacts.

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8 General / Administrative

The MOE shall conform to NPD 8010.2D, NASA Policy Directive, Use of the SI (Metric) System of Measurement in NASA Programs.

The MOE shall provide the capability to maintain version control for all MOE data.

The MOE shall provide the capability to produce and store data and products in a tabular, plot, textual, and graphics form

Rationale: generates and saves reports in product form

The MOE shall provide the capability to generate reports.

The MOE shall provide the capability to save and retrieve any report.

The MOE shall provide the capability to generate operator-defined reports and products based on operator-provided scripts.

The MOE shall provide the capability to generate one-time and regularly recurring reports and products at times indicated by operator-provided scripts.

The MOE shall provide the capability to print all data displayable on a workstation.

The MOE shall provide an anomaly reporting and status tracking capability.

All MOE capabilities shall comply with NPR 2810.1A, NASA Procedural Requirement, Security of Information Technology.

The MOE shall log all security events for the life of the mission, including successful and unsuccessful system access attempts, and file creations, deletions, and modifications.

The MOE shall provide individual operator account and password controls for access to the system and use of the software.

The MOE remote access interface shall be password protected.

**Rationale: Satisfies basic security requirements levied/described in NPR 2810.1A.
Reduces probability of telemetry pages being accessed by unauthorized personnel.**

The MOE shall have the capability to restrict operator access.

The MOE shall comply with the following subparts of Section 508 of the Rehabilitation Act (29 U.S.C. 749d), as amended, [36 CFR Part 1194](#)

Subpart A

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Subpart B 1194.21, 1194.22, 1194.26

Subpart C

Subpart D.

Rationale: compliance with accessibility requirements for software and selected hardware; also compliance with requirement from NPR 7150.2

9 Operator Interface

The MOE shall have the capability to provide video output of any workstation display to 3 or more workstations and/or video projection devices.

The MOE shall provide the capability for the operator to define and display customizable views of data and graphics.

The MOE shall utilize a Graphical User Interface (GUI) for system operation.

The MOE shall be capable of utilizing a command line interface.

The MOE shall provide the capability for a secure remote web interface for real-time telemetry, trending and analysis, and event/messaging MOE capabilities for at least 20 concurrent operators.

Rationale: facilitates support from ops and engineering personnel who are remotely-located from the MOC

During launch and early orbit, the MOE shall be capable of providing trending and analysis functionality for at least 10 concurrent operators.

Rationale: Of 20 total operators, 10 for sub-system and instrument support engineers/experts

During launch and early orbit, the MOE shall be capable of providing command and control, planning and scheduling, and flight dynamics functionality for at least 10 concurrent FOT operators.

Rationale: Of 20 total operators, at least 10 have the appropriate concurrent commanding, planning & scheduling, and flight dynamics functionality to support L&EO.

10 Automation

All functional applications in the MOE shall have the ability to run unattended while performing all routine and periodic operations for 96 hours.

Rationale: supports autonomous operations during 3-day weekend; assume schedules have already been made and command loads generated prior to going into autonomous mode.

All the applications in the MOE must be able to be managed via directives.

Rationale: running from directives generated via command line, application, activity schedule, etc.

All MOE applications shall generate and publish event messages providing alarm / warning / event information to indicate application state.

Rationale: Event messages shall be evaluated and responded to as defined by user.

The MOE shall provide the capability to autonomously distribute all products on a time or activity schedule basis.

Rationale: Minimizes operation intervention in the data distribution process.

The MOE shall be capable of autonomously establishing a command and telemetry link with an LGN station for every observatory-LGN contact.

Rationale: autonomy needed for unattended operations

The MOE shall be capable of ingesting CAPE input, scheduling and generating command loads automatically, when scheduled to do so by an operator.

Rationale: This is intended to support revision of data collection based on updated cloud cover predictions at CAPE in an autonomous mode.

The MOE shall utilize a service-oriented architecture (SOA).

Rationale: LDCM desires open architecture for extensibility, scalability, simplification of I&T, and autonomous operations

The MOE shall be capable of adding and removing MOE sub-systems with no loss in data or interruption to operations.

Rationale: enables modularity and scalability, plug and play architecture

The MOE shall provide standardized interfaces between sub-systems.

Rationale: enables modularity and scalability, plug and play architecture

The MOE shall provide standardized message-based communications between MOE sub-systems and applications.

Rationale: supports modularity, situational awareness, and autonomous operations

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The MOE sub-systems and applications shall automatically respond to start, stop, pause, heartbeat, and directive requests.

Rationale: basic level of support for all applications in the autonomous environment

The MOE shall provide the capability to monitor and report message traffic, system health status, and system configuration among and between MOE sub-systems.

Rationale: monitor communications between MOE functions in service oriented architecture (SOA) environment and provide status of MOE equipment and software (situational awareness)

The MOE shall be capable of generating alert notifications remotely to a communications/pager service.

11 Availability and Redundancy

The MOE shall provide system monitoring tools to track MOE system performance.

The MOE shall have a system up time availability for command and control operations of at least 99.9% (TBC9) averaged over 30 days, not including planned maintenance during non-contact time periods.

Rationale: MOE must be available to support around the clock observatory operations; excludes maximum total planned down time per month for performance of system maintenance

The MOE, excluding command and control operations, shall have a system up time availability of 99.5% averaged over 30 days, not including planned maintenance conducted during non-contact periods.

Rationale: MOE systems, non-critical to command and control, can have a less stringent up-time availability, and be scheduled for maintenance on a non-interference basis to mission operations.

The MOE shall have a mean time to restore critical command and control operations of 1 minute (TBC10) or less.

Rationale: ensures no loss of ability to command, control, and ingest telemetry

The MOE shall provide the capability to support training, testing, and system maintenance with no interruption to MOE functionality.

Rationale: to support training (including simulation), testing, and system maintenance and use of the observatory simulator on a non-interference basis.

The MOE shall be capable of operating with the observatory simulator concurrently with mission operations, with no impact to mission operations.

Rationale: specifically creates ability to use simulator while performing mission ops

The MOE shall provide the capability to log, track, and report system faults and failures.

The MOE shall provide the capability to report system faults and failures remotely to a communications/pager service

12 Backup MOE (bMOE)

The bMOE shall provide all the capabilities of the MOE as described in sections 3 through 11 of this document.

Rationale: the backup MOE provides all the functionality of the MOE. Note that section 13.12 specifies bMOE interface requirements.

The primary MOE shall communicate bi-directionally with the bMOE for data transfer, synchronization, and check-pointing.

The MOE shall be capable of transferring critical command and control data and information to the bMOE a minimum of once per 8 hour period.

Rationale: ensures command databases and other critical ops information are current and consistent between MOE and bMOE.

The MOE shall be capable of critical command and control data and information transfer to the bMOE within 1 hour from the start of the transfer.

Rationale: establishes time for updating bMOE databases and information

The bMOE shall be capable of transferring critical command and control data and information to the MOE a minimum of once per 8 hour period.

Rationale: when bMOE is serving as primary, ensures command databases and other critical ops information are current and consistent between MOE and bMOE.

The bMOE shall be capable of critical command and control data and information transfer to the MOE within one hour from the start of the transfer.

Rationale: establishes time for updating MOE databases and information, when bMOE is serving as primary

13 Interfaces

This section contains the MOE interface requirements. Figure 13-1 illustrates the MOE interfaces in the context of the overall LDMC mission and interfaces.

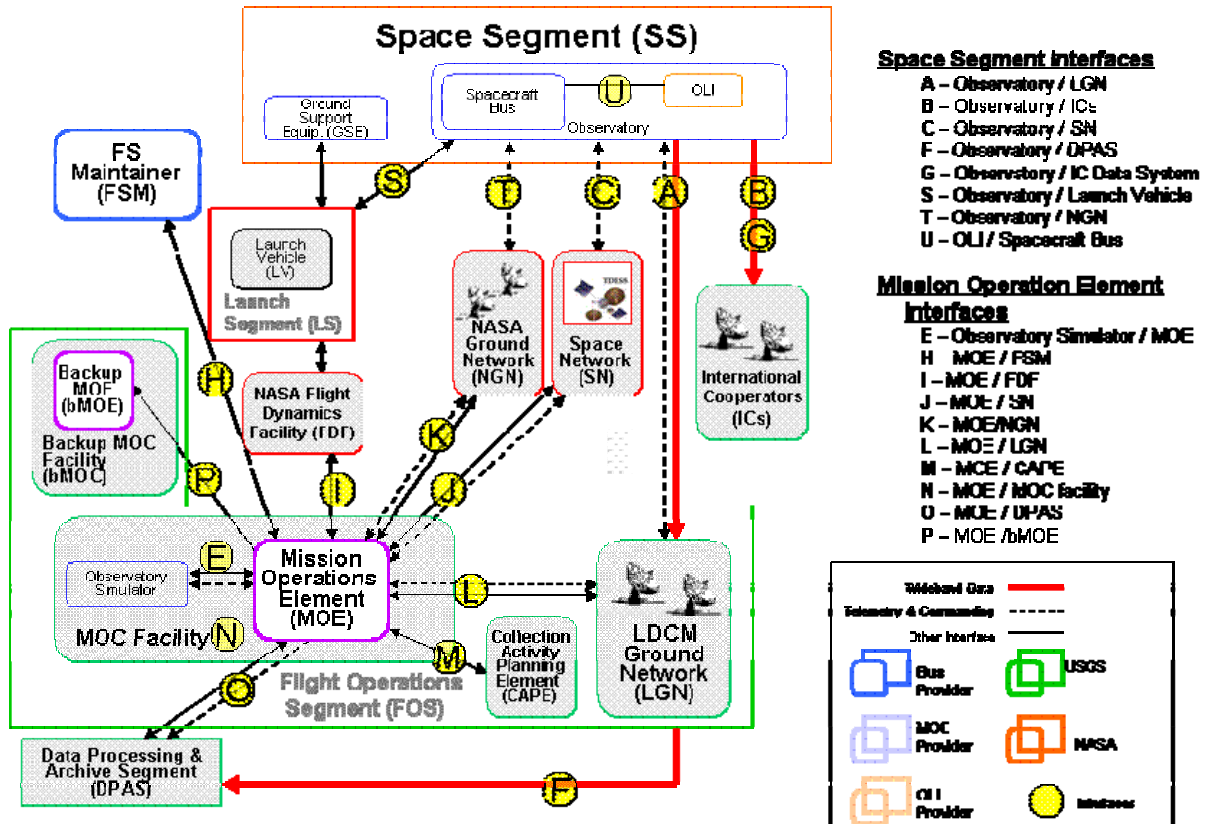


Figure 13-1: Mission Operations Element Interfaces

13.1 LDCM Ground Network

The MOE shall send forward and return link service requests to the LGN.

The MOE shall receive forward and return link service request responses from the LGN.

The MOE shall receive availability and status from the LGN.

The MOE shall interface with the LGN for forward and return link services in accordance with the following Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data Systems Standards:

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910.4-B-2 Cross Support Reference Model - Part 1: Space Link Extension Services,
911.1-B-2 Space Link Extension - Return All Frames Specification,
911.2-B-1 Space Link Extension – Return Channel Frames Service Specification,
911.5-B-1 Space Link Extension – Return Operational Control Fields Service Specification,
912.1-B-2 Space Link Extension – Forward CLTU Service Specification
912.3-B-1 Space Link Extension – Forward Space Packet Service Specification

The MOE shall send observatory commands to the LGN.

The MOE shall receive real-time housekeeping telemetry from the LGN.

The MOE shall receive stored housekeeping telemetry from the LGN.

The MOE shall receive return link quality information from the LGN.

The MOE shall send a list of all files comprising each interval to the LGN.

Rationale: This list is used by LGN to know when they have received all the files comprising an interval.

The MOE shall receive file-wise receipt status from the LGN.

Rationale: This allows the CFDP to close the loop. LGN will send MOE a list of CFDP files received during an observatory contact so MOE can command these files to be unprotected and available for overwriting.

The MOE shall send plans and schedules to the LGN.

13.2 NASA Ground Network

The MOE shall receive real-time housekeeping telemetry from the NGN.

The MOE shall receive stored housekeeping telemetry from the NGN.

The MOE shall send observatory commands to the NGN.

The MOE shall send scheduling information and acquisition data to the NGN as defined in the Ground Network User's Guide.

The MOE shall receive scheduling data/information from the NGN as defined in the Ground Network User's Guide.

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The MOE shall receive pass reports from the NGN as defined in the Ground Network User's Guide.

13.3 NASA Space Network

The MOE shall send forward and return link service Ground Control Message Requests (GCMRs) to the SN, consistent with the Interface Control Document between the Space Network and Customers for Service Management.

The MOE shall receive real-time network status/control messages from the SN, consistent with the Interface Control Document between the Space Network and Customers for Service Management.

Note: The LDCM MOC will interface to the SN for scheduling purposes using a Government-provided, SN-compatible scheduling system. The SN-compatible schedule system will be separate from the MOE. Scheduling information will be transferred between the SN and MOC consistent with the Interface Control Document between the Space Network and Customers for Service Management.

The MOE shall receive real-time housekeeping telemetry from the SN.

The MOE shall receive stored housekeeping telemetry from the SN.

The MOE shall send observatory commands to the SN.

13.4 Flight Software Maintainer

The MOE shall receive flight software updates from the FSM.

The MOE shall send table data to the FSM.

Rationale: to support flight software changes

The MOE shall receive table data from the FSM.

Rationale: to support flight software changes

The MOE shall send memory dump data to the FSM.

Rationale: to allow the FSM to see what is actually on-board, which may need to be compared to what the FSM thinks is on-board.

13.5 NASA Flight Dynamics Facility

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The MOE shall receive LDCM tracking data from the FDF.

Rationale: for anomaly resolution, FDF provides tracking data for LGN stations

The MOE shall receive predicted observatory ephemeris from the FDF.

Rationale: during launch and early orbit; FDF provides based on state vectors at LV separation; allows MOE to make contact with observatory

The MOE shall send predicted ephemeris to the FDF.

Rationale: supports Earth Science Mission Operation (ESMO) a.m. constellation coordination activities, and conjunction assessments.

13.6 Collection Activity Planning Element

The MOE shall send time-based resource availability, configuration and status data to the CAPE.

Rationale: observatory and ground system information needed for image collection planning

The MOE shall send the WRS path/row to time translation table to the CAPE.

Rationale: timing needed for image collection planning

The MOE shall send MOE system status information to CAPE.

The MOE shall send observatory contact opportunities (including projected downlink opportunities, uplink opportunities, and lunar calibration opportunities) to CAPE.

The MOE shall receive collection requests from the CAPE.

The MOE shall receive calibration requests from the CAPE.

The MOE shall receive scene management requests from the CAPE.

The MOE shall send plans and schedules to the CAPE.

The MOE shall send IC downlink schedules to the CAPE.

The MOE shall send scene ID to interval ID mapping tables to the CAPE.

Rationale: the MOE generates interval IDs, and the CAPE needs these to track data throughout the rest of the system.

13.7 Data Processing and Archive Segment

The MOE shall send housekeeping data to the DPAS within 12 hours of receipt at MOE.

Rationale: DPAS keeps a copy of housekeeping data for easy access by cal/val teams

The MOE shall receive DPAS availability and status from the DPAS.

The MOE shall send plans and schedules to DPAS.

13.8 Mission Operations Center Facility

The MOE shall be capable of operating on U.S. standard single-phase, dual-phase and three-phase electrical power.

The MOE shall be capable of operating in a temperature range from 50 degrees F to 75 degrees F.

The MOE shall be capable of operating in a humidity range from TBD4% to TBD4%.

The MOE shall receive an external IRIG-B (TBC11) master time signal reference from the MOC facility.

The MOE shall receive a fire walled public Internet connection from the MOC facility.

13.9 Observatory Simulator

The MOE shall send observatory commands to the observatory simulator.

The MOE shall receive housekeeping telemetry from the observatory simulator.

13.10 Observatory at Integration and Test Facility and Launch Site

The MOE shall send observatory commands to the observatory.

Rationale: The MOE must be able to send commands to the observatory while it is at the observatory I&T facility and at the launch site.

The MOE shall receive housekeeping telemetry from the observatory.

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Rationale: The MOE must be able to receive telemetry from the observatory while it is at the observatory I&T facility and at the launch site.

The MOE shall send database information to the Integration & Test Facility and the Launch Site.

Rationale: I&T developed databases can be transferred to the MOE for review and evaluation. This interface may require a re-formatting of the information by the MOE.

The MOE shall receive and accept database information from the Integration & Test Facility and the Launch Site.

Rationale: I&T developed databases can be transferred to the MOE for review and evaluation. This interface may require a re-formatting of the information by the MOE.

13.11 Backup MOE

The MOE and bMOE shall exchange data as necessary to support the transfer of operation between MOE and bMOE.

The bMOE shall support all the same interfaces as the MOE, identified in sections 13.1 through 13.9. (Section 13.8 is applied for a bMOE and bMOC interface.)

Rationale: the bMOE must provide the same capabilities, with the exception that it does not contain a simulator.

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Appendix A: Glossary

anomaly -- any unplanned or unexpected event which may result in a loss of operation data or a sharp departure of certain telemetry parameters from their nominal values – a deviation from normal operation that affects the performance of an observatory system or subsystem.

Activity – an operator-defined combination of ground directives and/or observatory commands which can be planned and scheduled. An action (or set of actions) which can occur on the ground or observatory that requires resources and is associated with a definitive start and stop time.

Activity Plan – a time-based set of activities that have yet to be schedules

Activity Request – a request for operators to schedule activities.

Activity Schedule – a time-based or time-tagged set of activities and resource allocations for a given time period.

Command Loads – a set or packaging of commands related by execution time and/or function, converted to binary streams to be up-linked. (Packaging of both telemetry and commands can be performed in a number of ways, such as the CCSDS Telemetry and Commanding Packaging format.)

Command Sequence – a set of commands related by time. A list of stored command mnemonics identified by a unique name known to the operators that can be re-used.

Commanding -- the coding and packaging of the command information, command validation and verification, as well as authorization to perform the commands. Telemetry and Commanding are necessarily related to one another because Telemetry and Commanding form a feedback loop; the values of down-linked telemetry may play a role in deciding what command or what command parameters to send next.

Commands – Messages that instruct an action on the observatory to execute.

Command Validation – The process of ensuring that commands have the expected results when they are executed by the observatory. Includes validating the use of command parameters associated with the command mnemonics.

Command Verification – The process of verifying that command mnemonics issued within command procedures and loads, and entered manually by the operator, result in the expected bit patterns being transmitted from the control center, as defined by the command data base. Includes verifying that the use of command parameters associated

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with the command mnemonics create the expected results.

Constraint Checking - The process of ensuring that constraints associated with the execution of individual commands or groups of commands are enforced, whether they are issued within command loads or procedures, or executed manually by the operator. Examples include: (1) ensuring that a particular command is not executed unless a particular on-board state is in place or a particular command had been issued before it, (2) ensuring that commands are not issued beyond some established command rate, and (3) ensuring that the number of commands allowed for a given structure, such as a command sequence, does not exceed an established limit.

Critical Command (or Critical Operations) – an observatory command which, when executed under certain conditions, could jeopardize the health and safety of the spacecraft or its subsystems. It requires the intervention/authorization of an operator before transmission.

Decommutated Telemetry – the extracted telemetry parameters from their assigned positions (such as the Major/Minor Frame Number in TDM telemetry systems or the Byte Position in a Packet within the Transfer Frame in CCSDS telemetry systems) within the telemetry stream.

Directive -- a command to the ground software system. Examples of directives are: bring up a display page, turn limit checking on/off, acquire telemetry, etc.
Engineering Unit (EU) – computed human and machine readable values for telemetry analysis. Examples of Engineering Units include values for voltage, temperature (degrees K or C), kilometers, etc.

Event – an occurrence detectable within mission operations systems that is used to monitor and track or otherwise audit ground and space operations.

Event Message – the resulting message from a detected event

Ground Reference Image (GRI) – the ground-based, controlled flight software version that is currently resident on the observatory representing all reprogrammable memory locations (i.e. the image/memory currently used by the On-Board Computer containing data, commands, subroutines, etc).

Hazardous Command – a command which when executed may endanger the safety of human beings working on the spacecraft during I&T, launch preparation or launch. The hazardous designation is made via the command database. Hazardous commands cannot be transmitted.

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Health & Safety – the discipline of monitoring observatory telemetry to check the well-being of the observatory.

Hot backup – an idle, but equivalent system or subsystem ready to take-over instantly when the primary system or subsystem fails.

Housekeeping Telemetry– observatory telemetry used in Health and Safety determination. Observatory housekeeping telemetry also includes instrument/payload telemetry.

Invalid telemetry - **telemetry that is not in a recognizable format and can not be decommutated or is decommutated but contains incorrect/invalid values, etc.**

Limit violation – an event when a telemetry parameter exceeds its expected range of values.

Log – A time-tagged list of actions or events

Memory Load —generally a combination of flight software updates, table loads, and command loads that affect the on-board observatory re-programmable memory locations.

Mission Operations Element (MOE) data – all data that is received externally to the MOE, sent out from the MOE, or created for internal MOE use. Examples include: all forms of Telemetry (e.g. Raw, Calibrated, etc), all forms of Commands and mnemonics, Pass Summaries, operator-saved analysis, event messages, plans/schedules, logs, etc.

Mnemonic – an alphanumeric shorthand representation of a telemetry point or a command assigned by convention and operators, and stored in a database to reference.

Observatory – The entire LDCM spacecraft including the bus, instrument(s) and any associated components.

Pass Summary – MOE data related to an observatory pass

Periodic operations – activities performed on a routine basis that require minimal engineering support

Planning – the discipline of predetermining and coordinating the mission activities for any period of time.

Procedure – A stored sequence of commands or directives written in a high-level language with built-in flow controls (such as if-then-else, do while, case, etc.) to automate observatory operations.

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Product - a report in tabular, plot, textual, or graphical form

Pseudo Telemetry – telemetry values derived by calculation often involving multiple telemetry points.

Raw Telemetry – telemetry that has not been converted into Engineering Units

Reports – operator-filtered MOE data output to a file, screen, plotter or printer

Routine operations – operations performed each contact or daily requiring no engineering support

Scheduling – the process of assigning and coordination of resources associated with planned activities, and the assignment of each planned activity to a specific time.

Scripts – a capability involving editable and stored sets of directives (see Directive) whereby mission operations ground systems administration can be accomplished automatically.

Special operations – operations requiring engineering and/or Flight Operations Team support.

Stale telemetry - telemetry that has old time stamps not synchronized with current system time.

State transition – an event when the observatory, one of its subsystems or telemetry parameters enters or exits an operator-defined, detectable condition

Stored Command – a command awaiting execution onboard the observatory.

Table Load -- An uplink of observatory parameters that typically reside in specific on-board memory locations

Telemetry – Includes housekeeping telemetry and pseudo telemetry.

Telemetry Counts – discrete values for raw specific telemetry points

Telemetry parameters – values used in the determination of observatory health and safety.

Trending – the discipline of tracking telemetry values for any number of recent or historical telemetry downlinks.

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